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Substitutability and Independence: Matching analyses of brands and products

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Abstract

This paper presents a comprehensive analysis based on panel data for 1847 consumers and 2209 brands of “biscuits” (a total of 76,682 records) in which matching analysis is employed to define brand substitutability and potential product clusters within the overall category. The results indicate that, while brands performed as expected as perfect substitutes for one another, five subcategories of biscuits into which the brands were divided (chocolate biscuit countlines, chocolate coated biscuits, filled biscuits, plain sweet biscuits, and savory biscuits) generally performed as a separate product. Matching provided a graded measure of substitutability/non- substitutability of brands and products, and thereby contributed to their definition.

Substitutability and Independence: Matching analyses of brands and products

Perhaps the most compelling intellectual challenge facing academic marketing understanding consumer behavior at the brand level. The key definitional point in branding is that there exist versions of a product that are sufficiently substitutable in the process of consumption that they compete openly and directly in the marketplace. The fundamental idea behind substitutability is that consumers will find alternative versions of a product functionally equivalent in the process of consumption. Distinctions here rest on subjective notions of what is functionally equivalent and, while this basic idea of functional substitutability is important in the work of Ehrenberg (1988), who explains multibrand purchasing in terms of the similar functional outcomes of selecting among various competing brands, a more objective approach might be of more value to marketing and retailing managers. Economists propose that an increase in the price of a commodity will result in an increase in the amount consumed of its substitute, whereas in the case of two complementary commodities a reduction in the price of one will result in an increase in the quantity demanded of both. This more pragmatic measure is, despite its operational validity, still confined to an analysis of quantity demanded as a function of price. A measure of substitutability more appropriate for marketing analyses would consider the substitutability, and hence inter-competitiveness, of brands within the competitive market. Unless marketing has an appropriate definition of substitutability and an operation measure that fits this definition, it cannot adequately address the brand level of analysis, that which makes marketing inquiry unique within the social sciences.

Substitutability, in its turn, is inherently connected with the ways in which consumers categorize products and brands, something which is central to their buying behavior as well as to the consumer-based structuring of markets (Ratneshwar & Shocker, 1991; Whan Park, Milberg & Lawson, 1991). However, the relevant critical features and category membership are not always objectively available to the researcher (Cantor & Mischel, 1979; Mervis & Rosch, 1981). Consumers undoubtedly categorize in ways that are subjective and individual in order to make sense of product classes; any tools of analysis and conceptualization that expand marketers' understanding of consumer-defined market structuring may, therefore, engender opportunities for more effective product positioning (Sujan & Dekleva, 1987; Adams & Van Auken, 1995; Rosa & Porac, 2002). This

paper is concerned with the capacity of matching analysis to provide an objective means of categorizing brands and products, which is based on consumers' observed buying patterns, and thereby to contribute to both the intellectual and practical demands of marketing as an element of human activity.

Matching, first reported Herrnstein (1961) and developed in succeeding decades as a fundamental component of modern behavioral economics (Herrnstein, 1961, 1970, 1979, 1997; Kagel, Battalio & Green, 1995), provides a means of defining and measuring substitutability and thereby of defining brands in contradistinction to product categories and subcategories on the basis of measures of consumer behavior. Matching refers to the tendency of animals and humans to distribute their responses between two choices in proportion to the patterns of reward obtained from each. If, for instance, in a choice of one of two keys, 70% of rewards are programmed by the experimenter to come from pressing key A, 70% of pecks or pushes will be allocated to that choice, the remainder to key B. The matching law was originally formulated as:

$$\frac{R_1}{R_1 + R_2} = \frac{r_1}{r_1 + r_2} \quad (1)$$

where R represents response rates and r respective reinforcement rates. Although the matching equation (1) above was successfully used to describe and explore behavior it was found that at some times less than strict matching could not be modeled by the above equation. To overcome this the Generalized Matching Law was developed (Baum, 1974) which was represented mathematically as:

$$\log\left(\frac{B_1}{B_2}\right) = s \log\left(\frac{R_1}{R_2}\right) + \log b \quad (2)$$

where B are the responses of behavior to choices 1 and 2 respectively, R depicting the rates of reinforcement derived from choices 1 and 2 respectively, b is a measure of bias, and s is a measure of sensitivity. Although both the logarithmic form and the non-logarithmic form of the equation are valid although the logarithmic form is thought to provide clearer (especially in graphical terms) patterns of deviations from strict matching. The parameter $\log b$ or *bias* constitutes the intercept of the linear log-log formulation of the law. Deviations of this parameter from unity are interpreted as indicating a consistent preference for one option independently of its reinforcement rate schedule. Such bias is

generally a result of experimental artifacts that could make one response less costly than the other. For example, in consumer situations the placing of brand on different levels of display (those at eye level generally sell more) or an out of stock situation may cause bias. The exponent s constitutes the slope and corresponds to a deviation from ideal matching ($s = 1$), indicating that the individual favors the richer ($s > 1$, overmatching) or the poorer ($s < 1$, undermatching) schedule of reinforcement more than predicted by the matching law (Baum, 1974, 1979). It is the s parameter which shows the level of substitutability between the reinforcers (Foxall 1999).

Hursh (1980, 1984) introduced the applicability of substitutability and other economic concepts with behavioral economics and the study of the matching law. Furthermore, research using matching analysis with qualitatively different reinforcers (e.g. food and water) has shown to be an exception to the predictions of matching law. When using qualitatively different commodities, as gross complements (i.e. when an increase on the consumption of one product requires the increase of the consumption of a second product, as is the case with food and water), it has been found that choice ratio has an inverse relationship with the reinforcement ratio, showing the exact opposite to what the matching law predicts (Hursh, 1978; see Kagel et al., 1995 for a review). Hence, this particular effect has been named *antimatching*, and in operational terms it consists of a result of $s < 0$ in the generalized matching equation. Under-, over- or anti matching are thought therefore to indicate some level of the independence or complementarity of the options (Green & Freed, 1993).

Matching has been particularly well researched in contexts that require an individual to allocate a limited period of time between two choices, each scheduled to produce reward at a different rate. Arrangements with two choices are termed concurrent procedures; those with more than two choices available are termed multiple schedules. Most choices for human consumers are rather different than those of non-human animals, requiring the allocation of a fixed income between alternative choices, each of which exacts a different monetary sacrifice. In this case, responses take the form of surrendering money in varying amounts, while the reward is the receipt of a fixed amount of the good in question. Price is the ratio of units of money that must be exchanged for units of the good.

Concurrent methodologies use both Interval and Ratio Schedules. Interval schedules require a certain period of responding before reinforcement is received, while Ratio Schedules a certain number

of responses. The assumption has been that the price structures faced by consumers resemble ratio schedules rather than interval ones (Foxall, 1999). For example a Fixed Ratio 30 schedule requires 30 responses (presses of a lever, pushes of a button, pence given) before reinforcement is given (a piece of food, a treat, a tin of baked beans). The prediction in the case of behavior on such schedules, in line with matching experiments with human and non-human participants, is that consumers should both match and maximize by always selecting the most favorable option, the cheapest alternative. That is, in a concurrent choice between a Ratio 30 schedule and a Ratio 60 schedule the more rewarding option is to stick to the Ratio 30 schedule as it requires fewer responses for the same amount of reinforcement.

Behavior analysis also uses the concept of fixed and variable schedules to analyze behavior (Hantula, 2001). A fixed schedule does not change and the ratio is constant while on variable schedule there is variability in the number of responses required to receive reinforcement. This results in two forms of schedules: Fixed Ratio (FR) and Variable Ratio (VR). Previous studies have suggested that prices do not generally change within a week or shopping occasion so a week by week analysis would be a FR schedule. However across weeks there is more variability in prices suggesting a VR schedule.

On concurrent VI VI (Variable Interval-Variable Interval) schedules where a variable number of responses are required matching is common becoming only slightly less common on VR VR (Variable Ratio Variable Ratio) schedules. On these types of schedules matching predicts, and numerous studies have confirmed that exclusive preference will not be found. A pattern of multibrand purchasing is found and so far has been supported in earlier studies (see previous work section below). This is a point of vital importance to marketing managers and also supports the work of Ehrenberg (1988), which suggests that repertoire purchasing is the normal pattern in human consumption choices. On the assumption that consumers choose rationally this may seem surprising but, as Herrnstein (1990) points out, consumers do not always act with full economic rationality and matching may better describe their actual choice patterns.

Although matching research has traditionally taken place using animal experimentation, a body of literature has grown confirming the applicability of matching to human subjects (for example Conger & Kileen, 1974, Borrero, Francisco, Haberlin, Ross & Sran 2007). Bernstein and Ebbesen

(1978) used the matching law to assess how much subjects engaged in a number of different activities while Buskist and Miller (1981) used a modified vending machine to study human matching. Myerson and Hale (1984) used matching to intervene in inappropriate behaviors and Redmon and Lockwood (1986) applied the matching law to organizational behavior. Pierce and Epling (1983) reviewed the available studies of human matching and found that there was great support for matching in the majority of studies however with slight tendency for more deviations from matching in humans rather than animals. More recently the matching law has been used to analyses the behaviour of slot-machine gamblers (Zlomke & Dixon 2006), social dynamics (Borrero, Crisolo, Tu, Rieland, Ross, Francisco, & Yammamoto, 2007) and sports (Romanowich, Bourret, & Vollmer 2007; Reed, Crtitchfield & Martens 2006).

Research on human matching in the context of consumption has involved experimental, field-experimental, and in vivo paradigms. Hantula and colleagues have undertaken a series of experimental studies involving a simulated shopping mall in which consumer choice under conditions of delay is consistent with matching and follows a hyperbolic distribution, as predicted by behavior analysis and behavioral economics (DiClemente & Hantula, 2003; Hantula, Brockman & Smith, 2008; Hantula, DiClemente, & Rajala, 2001; Rajala & Hantula, 2000; Smith & Hantula, 2003). Sigurdsson, Saervarsson and Foxall (in press) report studies of in-store experiments which monitored the effects on sales of manipulations of relative brand prices and other marketing mix elements including the positioning of products.

The Consumer Behavior Analysis Research Group at Cardiff University (CBAR) has been involved since 2000 in a series of investigations of consumer brand choice in natural settings. By and large, these analyses found both patterns: *brand* competition was generally marked by ideal matching, *product* choices by some degree of under-, over- or anti-matching. Similarly, though again with some exceptions, consumers maximized by purchasing the least expensive of the brands composing their considerations sets (Foxall & James, 2001, 2003; Foxall & Schrezenmaier, 2004; Foxall, Oliveira-Castro & Schrezenmaier, 2004). The exceptions occurred, first, because the composition of consumers' consideration sets often meant that their selections were among premium priced, higher quality brands, or at least those more highly differentiated through promotional activity, rather than

among all of the brands that made up the product category. As a result, their selecting the least expensive brand refers only to their choosing within the limitations of this subset of available product versions. A second source of exception was that some consumers bought more than one brand on a single shopping trip, often adding a rather more expensive brand to the cheapest within their consideration set. No doubt the different brands were intended for distinct situations of usage, as when a standard and less expensive fruit juice is purchased for consumption by children of the household in the course of the day and a more expensive version is obtained for the family's use at breakfast. The sheer desire for variety sometimes led consumers to select a more expensive brand on occasion, either in addition to or instead of the cheapest alternative. In the qualitative phase of the research one respondent reported that she "just had to" buy a distinctively-flavored brand of butter from time to time; another, that she would purchase a cheaper store brand sometimes even though this was not part of her regular repertoire simply as a result of the convenience of shopping at a different supermarket (Foxall & James, 2001, 2003). But, apart from these understandable exceptions, the predictions of both matching and maximization theories were fulfilled.

Although matching is a truism in the case of consumer choice; the more one buys, the more one spends, and at more or less constant prices the relative amount spent on one brand will be proportionally similar to the relative amount of it that is bought, these studies have clarified a number of matters in marketing and consumer research, and behavioral economics (Foxall, et. al, 2004; cf. Oliveira-Castro, Ferreira, Foxall, & Schrezenmaier, 2005; Oliveira-Castro, Foxall & Schrezenmaier, 2005, 2006). Romero, Foxall, Oliveira-Castro, Schrezenmaier and James (2006), for instance, investigated the expectations that product categories, which are not similar in physical formulation or functional substitutability, would throw up patterns of consumer choice that evinced under-/over-matching (in the case of complementary items), and anti-matching, (in the case of independent commodities). The results of this analysis broadly supported these expectations but a final conclusion on this matter awaits a more exhaustive investigation.

From these considerations, we devised two hypotheses for testing in the context of consumer choice. The first represented the expectation that consumers' patterns of purchasing for brands of biscuits would reflect the choice of substitutes; in this case it was hypothesized:

(H1) that matching would be found for brands, showing them to be perfect substitutes.

The second represented the expectation that subcategories of biscuits would behave like products rather than brands, evincing a pattern of choice characterized by deviation from near-ideal matching; hence, it was hypothesized:

(H2) that under-/over-matching would be found for each pair of subcategories of biscuits.

Method

Sample. The biscuits data in this study come from the ACNielsen Homescan™ consumer panel. The panel consists of 14,000 households and is representative of the population of Great Britain. Homescan™ panel members use hand-held barcode scanners to record grocery purchases brought back into the home and the purchasing information from each household is processed to ACNielsen's mainframe computer. This dataset provides the product category purchased, brand specification, date of shopping trip, store used, grand weight of items purchased, pack size, consumer panel number, consumer age, social class of each consumer, working status of each consumer, price per pack, quantity bought, promotion-specific information such as whether and in what way the item was on offer, and the total amount spent in each store. The data, for a period of 52 weeks from July 2004 to July 2005, yielded information on 1,847 participants who made 76,682 total purchases of 2,209 brands. Although data were available for four product classes the analysis was based on the biscuits category for two reasons. Firstly the sample size was significantly larger and secondly it was the product category that was most open to meaningful subcategories.

Procedure. The brands were sorted into five subcategories – chocolate biscuit countlines, plain sweet biscuits, chocolate-coated biscuits, filled biscuits, and savory biscuits – in line with industry conventions and the inspection of the brand data. The definition of each category, adapted from ACNielsen, Mintel, Euromonitor and Keynotes biscuit reports, is shown in Table 1.

Ten pair combinations of product sub-categories were developed for analysis from the five category combinations as shown in Table 2. For each separate subcategory pair analysis only those consumers who had purchased from both subcategories during the 52 weeks was included in that particular analysis.

Measures and analyses. In the marketing context, the matching law proposes that the proportion of pounds and pence spent for a commodity will match the proportion of reinforcers earned (i.e., purchases made as a result of that spending) (Foxall, 1999). The amount spent is a measure of behavior and hence forms the dependent variable; the amount purchased is a measure of reinforcement and hence forms the independent variable. In this context, the requirements of the generalized matching equation are fulfilled by expressing the ratio of the amounts spent on two brands (or products, or subcategories of a product) as a function of the ratio of the amount of each purchased.

Matching experiments have typically involved a simple dichotomous choice but consumers' consideration sets comprise a multitude of competing items. Therefore, the necessity of defining two commodities as required for matching analysis has been achieved by defining Brand A as that which during the period of the research was purchased the most, and Brand B as the amount spent/purchased for other brands within the consumer's consideration set. (Similar conventions were used for products and subcategories). Hence, the following ratio calculations were employed:

$$\text{Amount Paid Ratio:} \quad \frac{\text{AmountPaidforA}}{\text{AmountPaidforB}} \quad (\text{Dependent variable}) (1)$$

$$\text{Amount Bought Ratio:} \quad \frac{\text{AmountBoughtofA}}{\text{AmountBoughtofB}} \quad (\text{Independent variable}) (2)$$

The results were interpreted as follows. The s parameter on the generalized equation proposed by Baum (1974) was expected to vary according to the level of substitutability of products. In this sense, it was expected that the slope would decrease from near perfect matching for substitutable products such as margarine/butter, to antimatching for complementary products such as biscuits/tea. Following Baum's (1974) propositions, slopes between 1.10 and 0.90 will be considered near perfect matching. Slopes with values over 1.10 will be considered overmatching whereas any value between 0.90 and 0 will be regarded as undermatching, and values of $s < 0$ will be seen as antimatching.

The data were also analyzed in terms of both FR and VR schedules. Due to the amount of data, it was possible to use 1 week (FR), 3-week (VR3), and 5-week (VR5) integrations of the data.

Results

Brand choice within the investigated product category is characterized by close-to-ideal matching: slope, the s of the generalized matching law = 1.007 ($p < 0.01$); standardized beta = 0.95; $R^2 = 0.90$, adjusted $R^2 = 0.90$; intercept, the b of the generalized matching law = -.39 ($p < 0.01$). The value of s is so close to the maximal unity, which indicates ideal matching that there is no doubt that consumers are behaving as if the brands of biscuits that composed their consideration sets are highly substitutable. The fact that b is negative may be interpreted as indicating a preference for the “other” brands (“Brand B”), which suggests that consumers tend to spend proportionately more on the non-preferred brand. This is corroborative of earlier research on the elasticities of consumers’ demand for grocery brands, which indicates that consumers tend to buy smaller quantities of more expensive brands (Foxall et al., 2004; Oliveira-Castro, Foxall & Schrezenmaier, 2005).

Table 2 shows that for the FR schedule, in the case of the chocolate biscuit countlines and chocolate-coated biscuits the only case where matching was found. The VR3 schedule also showed a strong pattern of under-, and overmatching as contained in Table 2. The VR5 schedule showed mixed results with 3 out of the 10 paired categories showing matching, the rest showing a mixture of under- and overmatching. Matching was observed in the pairings of plain sweet biscuits and chocolate coated biscuits, plain sweet biscuits and filled biscuits and chocolate biscuit countlines and non-sweet biscuits.

Table 2 also shows that the values of the intercept ($\log b$), which can be interpreted as a measure of preference independent of the changes in the quantity ratios, for the FR and VR3 schedules were significantly different from zero for 7 out of ten pairs of subcategories and for VR5 were significantly different from zero for 6 out of the ten. For the FR schedule they were not significantly different from zero for the comparisons of plain sweet biscuits with filled biscuits and for chocolate biscuit countlines with savory biscuits, indicating no systematic preference for any item in each of these two pairs. Results for the VR3 and VR5 schedules are contained in Table 2. For the other comparisons, positive and negative values of the intercept indicate preference for the subcategory in the first or second column of the table respectively. Results for the FR schedule show systematic and transitive preferences among subcategories with savory biscuits and chocolate biscuit

countlines being the most preferred of all, followed by chocolate-coated biscuits, which in turn was preferred to filled biscuits and plain sweet biscuits. The latter two subcategories did not differ from one another. The results are also very similar for both the VR3 and VR5 schedules as can be seen in Table 2.

Discussion

These data confirm Hypothesis 1 and Hypothesis 2 for 9 of the ten pairs of subcategories in the FR analysis, all in the VR3 analysis and 7 of the ten in the VR5 analysis. The results are consistent with earlier research that has demonstrated matching for brands and deviations from matching in the case of products. The main indicator for further research stems from a discovery of an earlier investigation (Romero et al., 2006) in which an attempt was made to relate commodities on the basis of their substitutability, complementarity, and independence to the degree of matching, under-/over-matching, and antimatching that their purchase patterns exhibited. That study was highly indicative of the possibility of achieving this objective means of distinguishing commodities on this basis, something which the present analysis has addressed somewhat tangentially. Nevertheless, to the extent that it has been possible to investigate degrees of substitutability/independence among the commodities investigated, the present findings lend further credibility to the idea that substitutability, complementarity, and independence of commodities can be objectively measured in terms of matching analysis.

It is commonplace in marketing management as well as in marketing research to use labels referring to product categories as a matter of immediate convenience, to make use of such designations without appreciating that their breadth may be inimical to the accurate understanding of markets, and thereby to obscure the meanings of these terms for the consumer. Inquiring into the subdivisions that might exist within a product category might be seen by some as too philosophical an approach to the question of what is a product. The research reported here, however, makes it clear that within product categories there are subcategories that, given the patterns of consumer behavior we have demonstrated, should be treated more like brands, others that should be treated like products in their own right. While brands undoubtedly compete with one another, a factor that enters into their very definition, disparate products generally do not compete directly (except as each enters the contest

whose goal is the acquisition of discretionary income) (Romero, et al., 2006). The question how the components of what may be generically termed a product category themselves compete in a brand-like manner has not found a central place in marketing research and marketing practice. Nevertheless, it appears from the results presented in this paper to be a vital consideration in the interpretation of consumer choice. “What is a brand?” has a technical answer that we have sought in this paper to refine on the basis of how consumers behave, but it also has practical implications for marketing management.

The findings are central to the question of how brands and products are to be defined and, therefore, how they are to be marketed. For, knowing the marketing offerings with which one’s brand competes in the marketplace is a prerequisite of designing marketing mixes for it that will maximize its capacity to generate revenue and profit. The importance of the methodology employed lies in its basis in a theory of choice and measures of brand selection that have been objectively demonstrated in a variety of behavioral economic studies. They do not, therefore, rely on subjective evaluations of what constitutes brand and product categories.

We have applied a tried and tested theory and measure of substitutability at the level of consumer brands and products that clarifies the relationships among product categories, subcategories and brands. The implication of the failure to find matching in the case of the comparisons of subcategories is that product subcategories are more akin to products in their own right. The overall product category, “biscuits,” should therefore be redefined in terms of a number of separate products. The marketing significance of this is that we have shown which items are competing with which; our analysis reveals where the actual choices made by consumers occur, the structure of the market, and its cleavage in terms of brand and product divisions that make sense to consumers. The expectation that consumer purchasing of brands, but of not product subcategories, would evince matching is sensitive to nonprice elements of the marketing mix.

The research discussed here provides a both a replication of earlier studies (in terms of brand and product level analysis) and a replication with extensions in terms of the subcategory level of categorization. As suggested by Easley, Madden, and Dunn (2000) and Hubbard and Armstrong (1994), replications are vital to the advancement of knowledge and especially important in terms of

theory refinement. This study has refined the application of matching to consumer choice enabling it to be explored in a wider range of situation a consumer may face. It is hoped that the continuing replication of matching within areas of consumer choice as well as extending the applicability of matching and other behavioral economic theory to consumer situations will ensure a thorough refinement of the theory and provide the dependable foundation for further empirical work for which Evenschitzky, Baumgarth, Hubbard, and Armstrong (2007) argue.

There are instances, however in the results that points to the necessity for further research, and further replication and extension. This is the finding that for the FR schedule matching was present in the behavior of consumers for chocolate biscuit countlines and chocolate-coated biscuits and on the VR5 schedule for plain sweet biscuits and chocolate-coated, plain sweet biscuits and filled biscuits and chocolate biscuit countlines and non-sweet biscuits. These were the only results that failed to conform to the expectations inherent in H2. In order to interpret this finding further, we may fall back on the a priori classification of subcategories in terms of similarity of physical formulation. On the FR schedule it seems that the only pairing to show consumers matching is the only instance in which there is high face validity of the functional substitutability of the subcategories involved. On the FR schedule each of four the pairings that features savory biscuits vs. sweet shows undermatching, and in two of these cases the undermatching is marked, as indicated by the slope coefficients (Table 2). This, again, is consistent with there being sufficient face validity of dissimilarity between the paired subcategories to lead to the expectation of non-matching. The remaining sweet-sweet combinations of subcategories show more moderate under-/over-matching. On the VR5 schedule results are more confused and therefore further research is required to assess why this difference might be. It may simply be the case that aggregating the data may distort how consumers actually view and use it. In terms of possible future research it may also be useful to look at everyday non-food items (household cleaners, cigarettes etc) and more durable or high-end products (fashion goods, cars etc). However, in general, matching analysis is providing a quantifiable understanding and measure of commodities in terms of the degree of substitutability they evince, but further research, possibly involving an independent measure of consumers' perceptions of substitutability (see Romero et al., 2006), is required.

Conclusion

Brands are usually thought of as substitutable versions of a product category, though there is no objective means of defining brands or products prior to consideration of consumers' revealed preferences. Even then a great deal of arbitrary categorization is apparent in the determination of overall product classes (e.g., "biscuits," categories within them ("chocolate coated," and brands within those categories such as "Cadbury's Chocolate Fingers"). Work which has applied the methods of behavioral economics to the analysis of consumer choice has, however, led to the conclusion that matching theory (Herrnstein, 1997) provides a useful means of classification, and previous research, albeit using a small sample of consumers, has suggested methods of distinguishing brands and products that are new to marketing science.

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Table 1 Definition of biscuit subcategories

Subcategory	Definition
Chocolate biscuit countlines	They are individually wrapped chocolate-covered biscuit bars which can be sold in multipacks, including Penguin, Club, Breakaway, Classic, KitKats, Twix and Bisc&, etc., which are marketed and packaged both as confectionery and biscuits.
Plain sweet biscuits	Plain sweet biscuits are uncoated and unfilled but can be flavored, for example, coconut or even chocolate, including chocolate chips, cookies, digestives, sweet assortment, shortbread, shortcakes, wafers, coconut biscuits, tea & coffee biscuits and ginger biscuits, etc.
Chocolate-coated biscuits	Plain sweet biscuits coated partially or completely coated with chocolate (and only chocolate).
Filled biscuits	Sweet biscuits which can either be filled or sandwiched between two plain biscuits (with jam, fruit, chocolate or cream).
Savory biscuits	Non-sweet biscuits, like crackers, crispbreads, rice cakes, water biscuits and so on, are often flavored with salt or cheese or other savory foods and this category also includes cream crackers.

Table 2 Matching analyses for product sub-categories

Subcategory A	Subcategory B	FR1			VR3			VR5		
		<i>adjR</i> ²	Slope	Intercept	<i>adjR</i> ²	Slope	Intercept	<i>adjR</i> ²	Slope	Intercept
Plain sweet biscuits	Chocolate biscuit countlines	0.588	1.364**	-0.287**	0.759	1.778**	-0.328**	0.850	2.261**	-0.384**
Plain sweet biscuits	Chocolate coated biscuits	0.530	0.809**	-0.091**	0.744	0.878**	-0.105**	0.897	1.027**	-0.128**
Plain sweet biscuits	Filled biscuits	0.296	0.688**	0.041	0.399	0.799**	0.034	0.386	1.022*	-0.012
Plain sweet biscuits	Non-sweet biscuits	0.290	0.751**	-0.198**	0.164	0.643**	-0.168	0.155	0.828	-0.218
Chocolate biscuit countlines	Filled biscuits	0.732	0.734**	0.254**	0.805	0.881**	0.261**	0.857	0.843**	0.267**
Chocolate biscuit countlines	Chocolate coated biscuits	0.557	0.913**	0.126**	0.332	0.706**	0.135**	0.687	1.159**	0.110**
Chocolate biscuit countlines	Non-sweet biscuits	0.539	0.823**	0.007	0.849	1.185**	-0.058*	0.894	1.030**	-0.027
Chocolate coated biscuits	Filled biscuits	0.649	0.862**	0.139**	0.605	0.683**	0.150**	0.584	0.790**	0.145**
Chocolate coated biscuits	Non-sweet biscuits	0.162	0.522**	-0.046	-0.03	0.164	-0.002	0.070	0.350	-0.038
Filled biscuits	Non-sweet biscuits	0.452	0.762**	-0.219**	0.367	0.729**	-0.227**	0.384	0.760*	-0.235**

* p<0.05, ** p<0.01